

## PROPAGATION ANOMALY IN OVERSEA TV BROADCASTING WAVES POSSIBLY RELATED TO EARTHQUAKES

Toshiaki TAKANO<sup>(1,2,3)</sup>, Kurt SAKAI<sup>(1)</sup>, Satoshi UJIGAWA<sup>(1)</sup>, Han HIGASA<sup>(2)</sup>,  
Ikuro NAGASHIMA<sup>(1)</sup>, Hiroaki AKAIKE<sup>(1)</sup>, Youhei KAWAMURA<sup>(2)</sup>,  
Hiroyuki NAKATA<sup>(1)</sup>, and Shin SHIMAKURA<sup>(1,2,3)</sup>

<sup>(1)</sup> Graduate School of Science and Technology, Chiba University,  
Inage, Chiba 263-8522, Japan, takano@faculty.chiba-u.jp, Phone, Fax: +81-43-290-3311

<sup>(2)</sup> Faculty of Engineering, Chiba University,

<sup>(3)</sup> Center for Frontier Electronics and Photonics, Chiba University,

**Abstract:** Broadband spectra in the VHF band are observed to investigate any anomaly of propagation of distant TV broadcasting waves. TV waves from China, Philippines, Thailand and Malaysia can sometimes propagate to the observatory at Tateyama and they are classified into three types of propagation. Seasonal and daily variation of received waves was investigated through two-year observations. With these results and computer simulations, we may conclude followings: Malaysia and Philippines TV waves at lower frequencies are reflected by the F2 layer in the daytime ionosphere (Type A). TV waves from Malaysia and Philippines are scattered in midnight with plasma bubbles in spring and fall (Type B). China TV waves are reflected by Es layers in daytime in summer (Type C).

We found that TV waves from Malaysia at 48.25 MHz were sometimes heavily attenuated for a few hours when earthquakes occur in the Okinawa area. We propose a hypothesis that the attenuation is caused by some disturbance in the ionospheric E layer above epicenters. Results of computer simulations suggest that a 10% enhancement or depletion of electron densities can explain the observed attenuation.

**Key words:** propagation of electromagnetic wave, VHF wave, ionosphere, precursor of earthquakes, electron density in ionosphere

### 1. Introduction

Various electromagnetic phenomena have been reported in recent years, which are possibly associated with earthquakes. The observed frequency ranges of these phenomena vary from DC to VHF (Very High Frequency) as reported and discussed in the monographs [1-3]. The characteristics of these phenomena still have not been fully revealed yet because of the insufficient number of well-observed earthquakes.

We have observed electromagnetic waves in VHF band in Chiba prefecture, Japan, since 1999[4-7]. In this observation, we found long distance propagation of TV broadcasting waves, which was possibly affected by any ionospheric changes. But ionospheric

changes also occur under the influences of daily and annual solar activity, meteorological conditions, and so on. Therefore, we have to understand the behavior of the propagating waves under the normal conditions, and we observed long distance propagation of TV broadcasting waves for 2 years.

### 2. Observation system

We have observed radio waves in VHF band at Tateyama observatory in Chiba prefecture, Japan, which is located at the south end of Boso peninsula [4][5]. The observatory is on a small hill several kilometers away from the city area of Tateyama. A horizontally polarized 5-element Yagi antenna and a wide-band LPDA (Log-Periodic Dipole Array) antenna were used for the observations directed to the west in the horizontal direction. We observed 47.5-52.5MHz band using the Yagi antenna, and 50-76MHz band using the LPDA antenna. The altitude of the antennas is about 64m above the sea level. Received signal with the antenna was amplified with a pre-amplifier attached right under the antenna and transferred to an observation house by 50m-long coaxial cable. The gain of the pre-amplifier is about 25dB. A spectrum analyzer is used to obtain the spectral characteristics of the received signal. The analyzed data of every 20 seconds are stored on a hard disk of a personal computer.

### 3. Oversea TV Broadcasting Waves

#### 3.1 Identification of frequencies

Typical observational results are shown in Fig.1. Upper panel shows an example of the spectra in fall (October 23, 2001) and lower panel shows that in summer (August 15, 2001). The radio band including these frequencies is allocated in Japan to Japanese army, radio ham and emergency broadcastings and so on, and there exist no domestic broadcasting stations which regularly transmit radio waves.

### 3E2-3

In Fig.1, signals at several certain frequencies are received. Intensities of those signals change with time, but that at each frequency is fairly stable. Signals shown in Fig.1 have some side-band emissions in a few MHz. These facts suggest that these signals are TV broadcasting waves from outside of Japan and propagate occasionally with some favorable conditions in the ionosphere.

In order to ascertain it a TV broadcasting wave, we received the signal at 49.75MHz using a worldwide TV receiver and found it is the first channel of Chinese TV broadcasting in pictures. We identified the frequencies from other broadcasting stations. A cut of the spectrum at 22:00 of the upper panel of Fig.1 is shown in Fig.2. We can find many broadcasting stations were received. We compared these frequencies to TV broadcasting stations of surrounding countries of Japan. The identified frequencies from China, Thailand & Malaysia (CCIR) and Philippines are shown in Fig.2.

#### 3.2 Seasonal and diurnal variations

We observed these TV broadcasting waves for more than two years. Seasonal and diurnal variations of selected TV broadcasting waves are then shown in Figs.3 and 4.

#### 3.3 Types of propagation

We can classify these propagations of TV waves into three types as based on the frequency characteristics and seasonal and diurnal variations as shown in Fig.1. Type A propagation is observed in

8:00-20:00 JST in spring and fall and maximum propagating frequency fluctuates up to around 60 MHz. Type B appears in 20:00-24:00 JST in spring and fall at wide frequencies in the observing range. Type C is observed in summer mainly for China TV waves.

#### 3.4 Mechanisms of propagation

The distances from the observation point to the Chinese, Malaysia, and Philippines TV stations are 800km, 5200km, 2800km, respectively. Supposing that a broadcasting wave is reflected with one-hop by the ionosphere, the Es layer is required to reflect the China TV waves, and the F2 layer altitude is required for the Malaysia and Philippines TV waves. The height profiles of electron density in the ionosphere have seasonal and diurnal variation. Es layer becomes active in summer and the electron density in

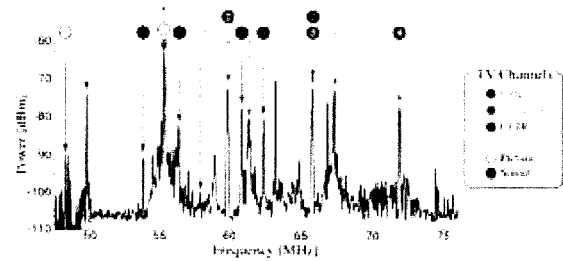


Fig.2. Received TV signal spectrogram at 22:00JST on Aug.15, 2001

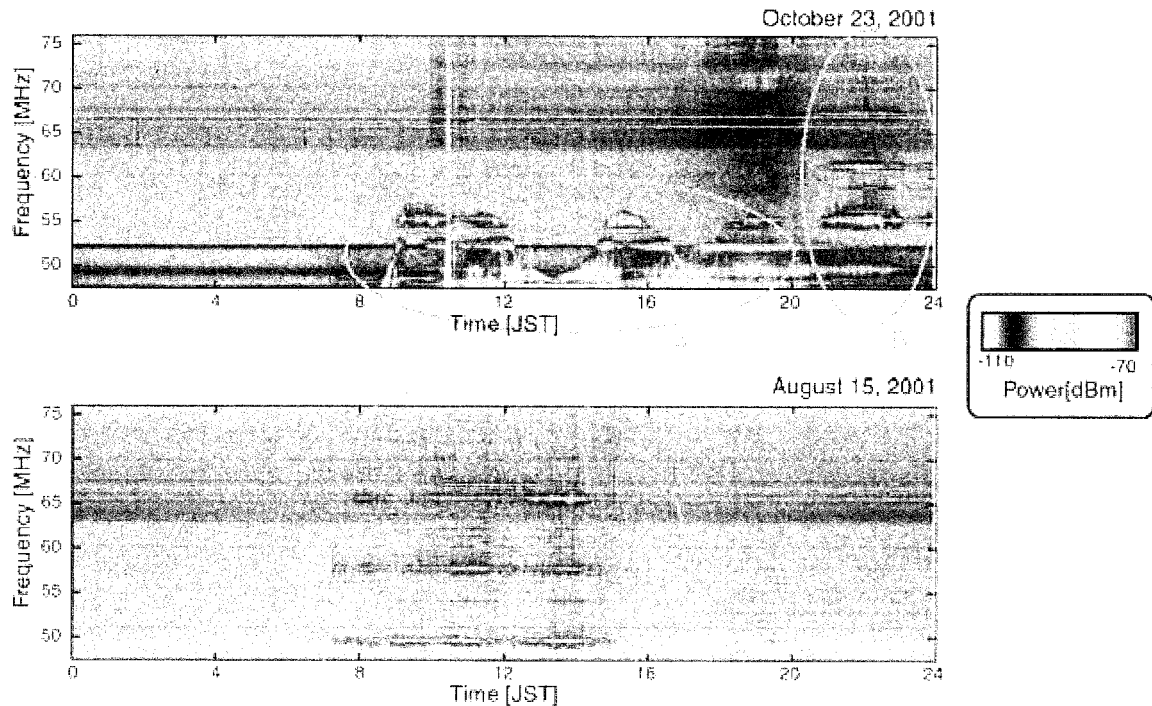


Fig.1. Typical daily spectra in spring (upper panel) and summer (lower panel)

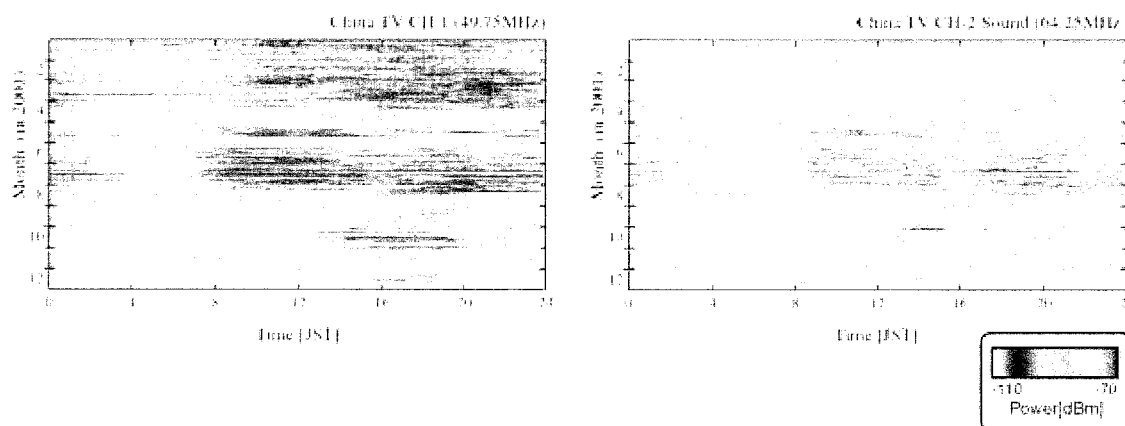


Fig.3. Variation of received TV broadcasting waves from China (49.75 & 64.25MHz)

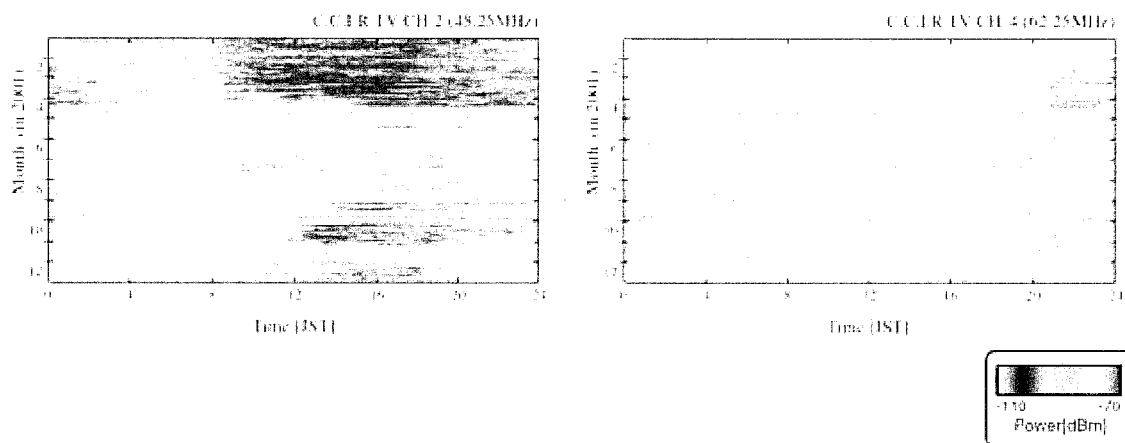


Fig.4. Variation of received TV broadcasting waves from Thailand and Malaysia (CCIR) (48.25 & 62.25MHz)

F2 layer becomes high in spring and fall in the area between the transmitting countries and the observatory. These characteristics seem to fit with the observed characteristics of each Type.

We are also performing computer simulations by means of the ray-tracing method. We have found that the F2 layer from daytime to evening in spring and fall refracts 50MHz electromagnetic wave. Moreover, diurnal variations of the maximum propagating frequencies are also obtained in the simulations, which are found to be in good agreement with the characteristics of observed Type A propagation. These facts suggest that Type A is mainly the Malaysia broadcasting waves reflected by the F2 layer. Type B propagation is possibly scattering with plasma bubbles, which emerge in the equatorial region in spring and fall. We made computer simulations of scattering with plasma bubbles as well as comparison to optical observations of bubbles. These results support this mechanism for Type B propagation. Type C propagation is caused with

sporadic E layer in summer in daytime.

#### 4. Abrupt attenuation of propagating wave associated with earthquakes

We have found that TV broadcasting waves at 48.25 MHz from Malaysia were heavily attenuated as shown in Fig.5. During the few-hour attenuation an earthquake occurred. We, therefore, searched such phenomena from 1-year observational data. As shown in Fig.6, earthquakes associating to the anomalous propagation of the Malaysia wave are located around the observatory and in the Okinawa area: southwest islands of Japan, which is along the great circle path from Malaysia to the observatory. We propose a hypothesis that the attenuation is caused by some disturbance in the ionospheric E layer above the epicenters in Okinawa as illustrated in Fig.7. Results of computer simulations indicate that a 10% enhancement or depletion of electron densities in E layer can explain the observed attenuation of propagating waves at 48.25 MHz.

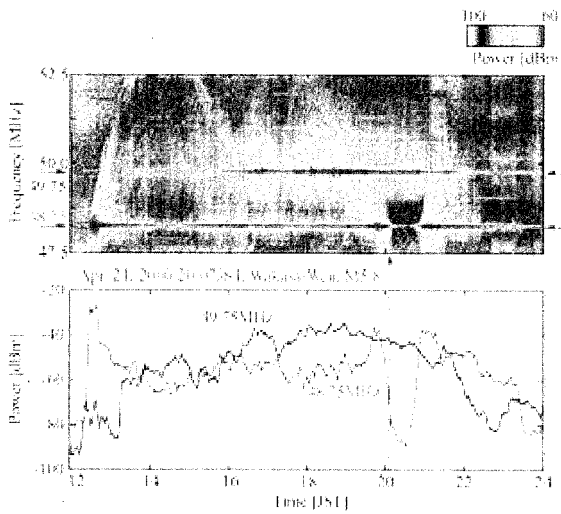


Fig.5. Abrupt attenuation of TV broadcasting wave at 48.25 MHz from Malaysia. An earthquake occurred during this attenuation,.

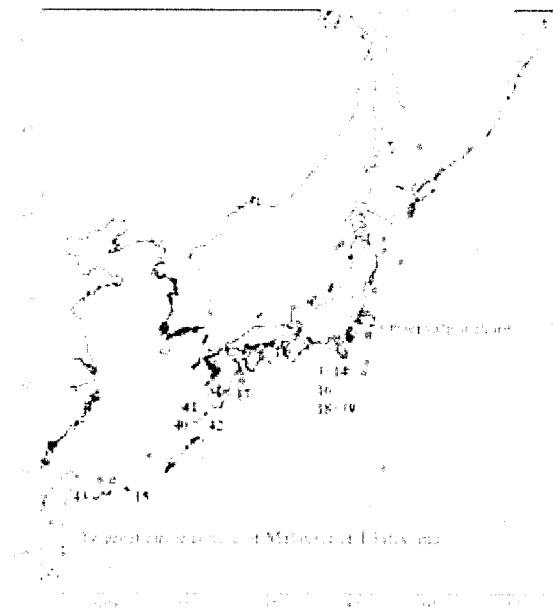


Fig.6 Locations of epicenters associating to the anomalous propagation of the Malaysia TV broadcasting wave at 48.25 MHz.

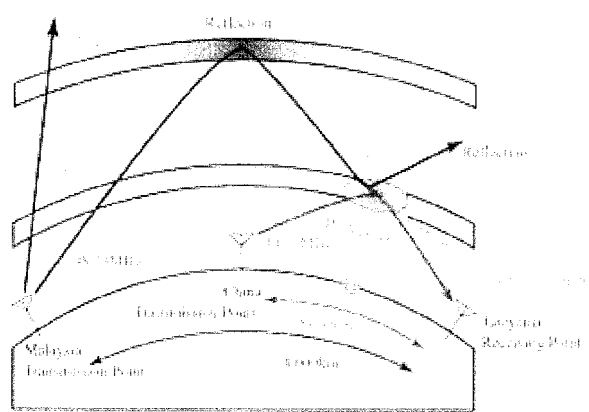


Fig.7. A hypothesis for the mechanisms of the anomalous attenuation of the Malaysia TV wave.

References

- [1] M.Hayakawa and Y.Fujinawa, eds., “*Electromagnetic Phenomena Related to Earthquake Prediction*”, Terra Sci.Pub.Comp., 1994.
- [2] M.Hayakawa eds., “*Atmospheric and Ionospheric Electromagnetic Phenomena Associated with Earthquakes*”, Terra Sci.Pub.Comp., 1999.
- [3] M.Hayakawa, O.A.Molchanov, eds., “*Seismo Electromagnetics : Lithosphere-Atmosphere-Ionosphere coupling*”, TERRAPUB, 2002.
- [4] K.Sakai, H.Higasa, T.Takano and S.Shimakura, “Observations of Anomaly in Oversea Long Distance Propagation of TV Broadcasting Waves”, *IEE of Japan, Trans. Electronics, Information and Systems Society (C)*, Vol.123, No.1, 2003.
- [5] K.Sakai, T.Takano and S.Shimakura, “Observation System for Anomalous Propagation of FM Radio Broadcasting Wave Related to Earthquakes and its Preliminary Result”, *J. Atmospheric Electricity*, Vol.21, No.2, pp.71-78, 2001.
- [6] T.Takano, A.Yamada, K.Sakai, H.Higasa and S.Shimakura, “Enhancements of Electromagnetic Broadband Noise in 50 MHz Band Which Possibly Associate with”, *J. Atmospheric Electricity*, Vol.22, No.1, pp.23-34, 2002.
- [7] T.Takano, Y.Yaji, and K.Sakai, “Spectrum Analysis of Anomalous Propagation of FM Radio Broadcasting Waves Possibly Related to Earthquakes”, *J. Atmospheric Electricity*, Vol.22, No.3, pp.257-275, 2002